HARALD BODE'S VOCODER

This is the seventh of a series of exhibitions, the first of six of which have been taking place at the Experimental Television Center in Owego..It is a series of exhibitions and seminars on the Electronic Arts, by Video makers. This evening we have the pleasure to have Harald Bode here, who has been involved with with Electronic Music, instrument building, for a number of years. Before I mention more, I have a little mmore about the introduction of his work; I would like to just put in a plug for another set of shows...there will be a video festival taking place at the TV Center, the show of the Video CAPS recipients....etvc

The event this evening, in addition to being sponsired by the TV Center, is also being sponsored by the Cinema Dept. here at SUNY Binghamton, and also by the Music Dept.

I have an article, one of three articles, that were written about my guest this evening, by Tom Ray, in Contemporary KeyBoard Magazine and I'm just quickly going to paraphrase from this first paragraph because it is a good intro duction: " Harald Bodes's career spans three distinct eras in electronic music instrument design. His Varbo format organ came toward the end of a decade in exploration in Germany during the thirties.. His MelloChord found its place in the first electronic music studio in Cologne, Germany, in the early fifties. Now this designer builds sophisticated rack-mounted equipment such as the frequency shifter and the Vocoder."

This evening's demonstration is going to be of the Vocoder. As one reads through the first three articles, something that's really very interesting and that we're coming to value even more, can be summed up in three categories in some way. When one looks over all the pieces of equipment that Mr. Bode designed over the past few years, all of them were electronic devices built for musicians and artists to use, so the devices weren't meant for thecommunications industry or for applied

scienctific work, they were meant for artists to make music. Also, as one looks through the range of equipment, the actual concept andnature of the machines, the actual is very significant and interesting and engaging, by virtue of theKIND of sound processing that's involved, that just by themselves, the systems are interesting devices. And thirdly, in each case involved, they were engineering successes and feats in their time. That altogether, the idea of dealing in technology and the arts, is something that Mr. Bode has been involved with from very early on, and he is certainly one of the initiatprs in that area. So, it gives me great pleasure to introduce Mr. Bode, someone whom I've known for many years.

Now, if I talk about the Vocoder, if I think of how to explain the Vocoder to the layman, many people don't know what the Vocoder is, so I use some simple terms. For instance, the Vocder is a machine which can make Walter Cronkite sing the news. And to jump back into it, I have a proof here. I have a recording of Walter Cronkite singing the news. (TAPE)

The Vocoder can do a lot of things and I am going to give you some samples of tape reordings. This, for example, a sample which is done with a polyphonic synthesizer, the Polymoog, where I can make the VOcorder sing like a choir. Now, I can also sing a solo voice and the trick is that I'm not really singing. I'm only speaking into the microphone and giving the articulation of my voice and everything is being done by translating process in the Vocoder. So, I;m having another sample here which is done by a monophonic synthesizer.

Now, how does all this happen? What really does make the Vocoder sing? I can best explain this with a few slides.. The Vocoder, for those who can read a schematic diagram, and this is a block schematic, analyzes the speech and slices the speechup into a number of,,,rather, the spectrum of thespeech, up into a number of channels. In this case, in the case of the Vocoder, which I am going to demonstrate live at a later point in

the demonstration, has sixteen channels. These 16 channels extend from 50hz to 5000 hz, which are the essential range for the intelligibility of the speech. The speech is then, after it is analyzed, and after the characteristics of the speech are extracted for the various overtone ranges, in these control voltages, are entered into a speech synthesizer, which makes the speech, however, with a substitute sound, which I can call a carrier, iran excitation source. In this case, I had a synthesizer, a monophonic synthesizer, as an excitation source.

In more detail and when you see the voice input on the left side, the voice is fed into a number of band pass circuits, which are called band pass one, two and sixteen and all the other band passes in between.. Now these band pass girters have a width, with the exception of band pass one, of one third of an octave. And these, the overtone amplitudes, the overtone energies, of each of these band pass regions, are fed to four wave rectifiers and ripple filters also considered as envelope followers..

At the right side of the envelope followers, we have control voltages coming out and these control voltages are entered into the control inputs of voltage controlled amplifiers, V.C.A.'s, which regulate the energies received of the preceding band pass filter BP, where we began on the right side (ONE, MY ADDITION), through sixteen, which in turn receive the carrier input signal. The band pass filters, one through sixteen , on the right hand side, correspond in frequency exactly to the band pass filters one through sixteen on the left hand side..

So, this way, the spectrum is being remade, fed through the mixer, which receives the sum of all the signals. Also, a portion of the voice signal is by-passed directly. This is the part which is about 5000 hz, and which is not important for pitch information, but which is important for the consonants, such as the s's, which are in the hi gher frequnecy range.

Now, here we have in the upper diagram, the forty analyses of the spectrum analysis of a male voice singing the vowel ah, and now, this spectrum hits the analyzer filters, which a re in the diagram below. The contour of the analysis of the spectrum analysis i s now transfereed and transformed into control signals, which are shown as arrows with different amplitudes between the analyzer filters and the syntesizer filters.. Then these control signals control the synthesizer, are the input signals, that hit the synthesizer filters. In the bottom diagram, we see the resulting synthesized wall which resembles quite closely the wall shown in the upper diagram.

Next slide....Essentialy this shows the same analysis, only in a different scale. The first scale of the preceding slide, was a linear scale and this is the exponential scale, which makes all the band pass filters appear in an equal width., which is one third of an octave, which I said before. Again, you see the reconstruction of the analysis of the lower diagram, from the analysis the upper diagram, through the process just described.

The Vocoder hasbeen around for quite a while and the additional Vocoder by Robert Dudley of Bell laboratories and he has done some quite remarkable work.. I have been given by Dudley, a tape, of which I copied a small excerpt, just a few test sentences. I have to interject, here, at this point, that the Dudley Vocoder of the 1939 vintage, was not intended for electronic music purposes, but for compressing the band width of transmission for speech transmissin. The speech signal was sliced into so many control voltage components, which could be transmitted through much narrower channels, than the three thousand required for telephone transmission. So this, I'm going to show you now shows you a sample of speech, Vocoded speech, of the Bell Telephone Vocoder by Dudley, and compare it with natural speech. This type, I must say, has been copied from a wax master so you have to excuse the noises that go with it.

TAPE SAYS " Speech is now being remade by analyzing the talkers speech with the fundamental speech information and then using this information to remake the speech with a synthesizing device. The entire process is being carried out auto matically and almost instantaneously by electrical circuits. The apparatus used has been called a Vocoder, because it operates on the principle of coding the voice and then reconstructing this voice accordong tp this code. The process consists ofa speech analysis followed by a speech synthesis. These have been separately studied by many workers in a wide variety of fileds.. For example, neurologists, phonéticians, elocutionists, laryngologists, and communication engineers. Sister susie selll sea shells down by the sea shore, etc. "

So much for the Dudley Vocoder, which really for its time, was truly remarkable. Now, if we don;t want to use the Vocoder for the tran smission of speech, but for entertainment purposes, for musical purposes, we had to follow some other directions, which were connected with intelligibility, of course that was here too (In the Dudley Vocoder, my addition), speaker recognition and good qualities formmusicalpurposes.

We don' t absolutely want to limit ourselves with speech reproduction or simulation, but we also wanted to do other things with the Vocoder, which we can show at this point. Now, first I am going to go in small steps. First I am showing the speech simulation, where I simulate the pitch of the voice, the inflection of the voice, by hand-tuning a dial. Then I am going to use an excitation source, not a synthesizer, not the tone part of the synthesizer, but the white noise part of the synthesizer. So let me show these two exapmple....(TAPE)

Now, I already have a synthesizer going into the excitation input. I had a polyphonic synthesizer. What happens if I play something very fast, as fast as I cannot even sing.. Something like toned sequences that are generated by a sequencer. Or let's make it more interesting. Let's

put 2 sequencers into the carrier input and then just put some articulation with my voice into the voice input.

(TAPE !)

The preceding feature has been obtained by feeding the sound of a rythm ddevice into the voice input and an electronic organ into the carrier input. The following section has been recorded with my voice into the voice input and 2 sequncer-controlled V.C.O.'s into the carrier input.

(TAPE) we have

So, quite anumber of applications, I would say. And , of course the Vocoder is not alone to be complimented for this. This little eclectronic music stidio also was part of it. Show the slide now.

This is the vocoder. You see it there in a set form without all those table that you see. I'll explain those table to you later.. They are there for making cross patches. And that is going to come in the latter part of the demonstration..

So, next slide..... This is part of my synthesizer equipment... and the central part of my studio. You see the Vocoder sitting up in the upper right hand corner on the low edge is a multi-pan modulator which is quite an interesting tool, but it's not going to be demonstrated today. On the left side of the Vocoder is a frequnecy shift delay- line modulator, below that is a portion of the moog synthesizer , and below the Vocoder, further below the multi-pan modulator, you see a custom made unit, which has three modulators...filters and things like that, Andbelow the whole thing, about the keyboard, are some sub-mixers, as you have fpr the synthesizer application.

Next;;;; This is a little hard to see because the lights are on, but I think it's enough that you recognize that there's a little bit more ofthe srudio than just myself. On the tight hand you see the polymoog

keyboard, in the rear right corner you see an 8 track recorder.

Next slide, please....That's me playing an army game with the mic and synthesizer.. I'm playing on the poly moog even with out doing anything with the Vocoder. I like doing that alone too, as it is.

On the top of the polymoog, you recognize the present device, the one that you just heard and not unrecognizable on the right side of the rythm device, is a programmer of sequential circuits..

I'm talking into the mic and making my choir. And here you recognize the mixer a little better on the left side of the rythm device and the background between my nose and the mixer is the controls of the rythm device.

I have one more thing with the sequencer, which I just showed you. I can do the same thing: rather than singing into the microphone, and putting drums into the voice input.

(tape)

Now I haveto point out one thing, you will hear the speed of response. This is not anything to be taken for granted. It's a special development on this Vocoder which makes it so responsiveand thus usable for percussion instruments. The response time and the range, up to 5000 hz, is about one millisecond and above 5000 hz, it is zero, ABsolutely DIRECT. And this makesit extremely well suited for percussion instruments. But not only percussive sounds.. Becausenow we have seen something else. We have seen the simulation of voice, the simulation of drums. We have heard the [illegible] example with the whistle. Now what happens if we put an instrumental sound into theh voice input and the synthesizer sound into the carrier input or excitation input? Does it simulate a violin sound, for example? You be the judge. I have a few examples. (Tape)

Now the next one is especially interesting because the pizzicato sound is very hard to synthesize.. TAPE

So much for this.

Now I'm going to have you take a peek into my studio by the means of video tape/

Now before I go to the live demonstration of the Vocoder, I propose we have a little intermission and then together with the live demonstration comes a question and answer period.

(TAPE) I'm going to play a few notes on the synthesizer, it happens to be a multi-Moog and while I'm doing this I'm also going to show a a few features which I didn't explain before. SING

Now, we have Donald Duck singing the same thing, How this is being done with a so-called cross patch here which is why I have all these wires here, so I can connect the filters from the analyzer output and now I try filters on the synthesizer input which are offset in frequency so I have a kind of transposition of the front end regions of the overtone regions to a higer place.

VOICE

I have been mmemorizing now the analysis of my overtones of my voice.

Now I'm going to say anther rund. (VOICE) ee-oh

I can do this with Donald Duck's voice too. First I have to enter something and then I can memorize it.

So much for the live demonstration of the Vocoder. I have a little second peek into my studio . Then questions.

"This is Harald Bode speaking. I am now here in my little electronic music studio andI emphasize the word little but this doesnt mean as far as the possibilities of this studio is concerned, it only means as far as the space that it takes, Other wise it has quite some possibilities, as you will find out very soon when I demonstrate the various instruments.

First of all, you have a relatively familiar view. This is my monophonic synthesizer. It's a hybrid synthesizer, comprising the Moog keyboard, some essential Moog modules, some sub-mixers, a signal processor of a kind which I built way back in the sixties sometime, which is comprised of two ring-modulators, attack and decay generators, white noise oscillators, filter, and vibratoo oscillator and modulator. Then I have a Bode frequency shifter which is this instrument here, then I have added a Bode Vocoder, which is very interesting and potent in strument. Below the Bode Vocoder I have the Marshall time modulator, which among other effects does phasing, flanging, voice doubling and tripling, delay effects, reverberation effects and the like.

Then on top of the synthesizer I have two polyfusion sequencers, Here is another voltage controlled oscillator and here I have a sequencer, 256 note sequencer by sequential circuits.

Now, of course, I want to record the things that I am doing here, so I havean eight channel tape recorder, an eight in and four out mixing board and behind the mixing borad, I have a switching and patching center, which is for the whole studio including the thing that we haven't seen yet on the opposite side andalso these things that we are seeing now, on this side.

I have a polymoog ~~synthesizer~~ keyboard, I have another BodeVocoder, I have a (INCOMPREHENDIBLE, SOUNDS LIKE " DIRRFEN DEGUISE" ???))), also called a sideman.. I have a (INCOMPREHENSIBLE) by sequential circuits, which I'm not going to demonstrate todaybut which is another unit which works together with the contraption with the synthesizer. And now I'm going to the other side of this room, I have my master tape recorder, which is here and I have a tapeloop reserve unit; a tape loop that then has to be us ed loosely, beaause it's really a supply reel and takeup reel device and a multiple head device, which you will hear later in

operation. Down below I have a submixer, and then I have the normal paraphernalia, like a turntable, another high-fi recorder, very good recorder and a cassette tape recorder.

So this is it in A nutshell and now I'm going to give you a few demonstrations of the various pieces of aquipment and the combinations thereof.

" This is just a little peeek inot my studio."

So I guess you may be loaded with questions and I'd be more than happy to answer anything, as well as I'm able to,

Q: I wanted to ask about the string sound. I'm not clear about that. What was the live sound and what was the part that you fed into the Vocoder...What were the two sources ?

B: I can of course, re-do something, here on the tape. The live spund, of course, was the monophonic sound, which I think came from this speaker here. The violinist is playing one note and this note was recorded first. Incidentally, this thing was done without any practice, it was just done improvised. It was recorded on one channel of the two channel recorder. Then the recorder was put into the playback mode and the string sound was entered into the voice input of the Vocoder. And then into the carrier input, I fed the two synthesizer notes. Incidentally, I used the trick playing the synthesizer duo-phonic. I used the two sequnecers that you saw on the top of my assembly with two controlled voltage oscillators and they were tuned to a sequence of tone-intervals. The voltage-controlled oscillators, both of them, dod not only accept the control voltage of the sequencers, but also of the monophonic keyborad, so I could now, withthe given interval, say a fifth or so, that I had just selected on the sequncer, I could now play thisinterval of one fifth up and down on the Moog keyboard. So it sounded like really playing two

synthesizers, which was not the case. It was just a trick. It works pretty nice, musically. I can repeat it. If you can listen to an interval taking place, or being played for so many notes, until you change the interval and play another interval, for so many notes, which is again pre-selected by going to the next step on the sequencers, which can be done with the step switch.

So, these synthesizers, these two synthesizer notes, were put into the excitation input of the Vocoder and provided the pitch with sufficient overtones and the overtones from these two notes were then formed to correspond to the overtones of theviolin, so it sounded in the putput like two noew violins being amped. And I can repeat this because I have the tape. And I can also change back from channels, to additional and playback, rather , processing. (TAPE)

But what you just heard was one tone interval and being maintained throughboth notes going in parallel due to the control From the Moog keyboard. (TAPE) I tried to adapt myself to the playing techniques or tone sequnces which are natural for violins and keyboardds.

AUD"" The violinist was playing just one note...?

" Just one note and this was an extremely interesting case, because that was just one note. Incidentally, I don't know if I should promote her as a violinist, but Steina Vasulka played the violin, And I also have to give her credit for making those video tapes. So you use the one note as raw material and from that tone, you process it."

Q: So are you also playing the keyboard, or it is..."

ANS" Yeah, she was just playing that one note and then I played back thetape recorder in the mode that plays back on one track and records on the other track, so I added these two voices, improvised these two voices, through the first voice.

The control voltage should always be rich in harmonics. And, of course, if I have different wave forms on the control signal....That's what you mean, is it not ? You mean the carrier signal, the excitation signal, that I put into the carrier input...or...

Q: No, I mean the voice input. You derive the control volt use, you sample the voice from.... Bode: Oh, I devise control voltages from the spectrum of whatever instrument it is. Whether it's voice or violin or anything else. And, of course, if I would, if these ~~control~~ control voltages would not change with time, I'm just trying to imitate a spectrum with my , rahter , fluctutations of the spectrum, with my fingeres here..

If that wouldn't happen, then it would sound like an organ string voice on an electric organ. Which is dead. Which is not a string vooice. But a real string voice goes through fluctutaiotns all the time in its tone analysis. Just like the human voice. The human voice is not a dead thing. It's changing all the time so the tone analysis of a human voice is changing all the time. So you have to capture and sample a the changes of the spectrum all the time and this is what makes a Vocoder so human sounding, in contrast to any speech synthesis that otherwise attempts to simulate the human voice.

Q" Let me make sure Im' clear on thispoint. You have your frequency analysis of the voice, say violin,,,BODE: The overtone analysis. YES BODE: For 16 channels and a channel may count for more than one overtone. Q: But these are different amplitudes. BODE: Yes

Q: Do they modulate the excitation signal in those same ratios ? Bode: Yes. It's actually anamplitude modulation. Each channel amplitude-modulates its share of the overtones.

Q" So. it takes whatever is coming in for excitation and shapes that (whatever) sound into the shape of the ...BODE: of the initial voice or instrument or whatever.

Q: But you also say that and I think that I saw it in the demonstration of the graph, that the result was a stable signal. BODE: Yes, because these natural instruments go throughall kinds of fluctuations in their tone spectrum.. That is why it is so hard, as I said before, to simulate them with any conventional means. There is more to, it, to simulate a tone. Well, this is it. You are welcome to come up and play with this set-up or ask further questions of me... Thank you.